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ABSTRACT

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REPORT No. 147
DECEMBER, 1972

LEARNING GAMES AND STUDENT TEAMS: THEIR EFFECTS ON STUDENT ATTITUDES AND ACHIEVEMENT

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The Johns Hopkins University

Baltimore, Maryland

INTRODUCTORY STATEMENT

The Center for Social Organization of Schools has two primary objectives: to develop a scientific knowledge of how schools affect their students, and to use this knowledge to develop better school practices and organization.

The Center works through five programs to achieve its objectives. The Academic Games program has developed simulation games for use in the classroom. It is evaluating the effects of games on student learning and studying how games can improve interpersonal relations in the schools. The Social Accounts program is examining how a student's education affects his actual occupational attainment, and how education results in different vocational outcomes for blacks and whites. The Schools and Maturity program is studying the effects of educational experience on a wide range of human talents, competencies, and personal dispositions in order to formulate -- and research -- important educational goals other than traditional academic achievement. The School Organization program is currently concerned with authority - control structures, task structures, reward systems, and peer group processes in schools. The Careers and Curricula program bases its work upon a theory of career development. It has developed a self-administered vocational guidance device and a self-directed career program to promote vocational development and to foster satisfying curricular decisions for high school, college, and adult populations.

This report was a cooperative project of the Academic Games and the School Organization programs. It is one of a series that investigates the effects of using learning games and student teams in the classroom. This report examines how games-teams, combined and individually, affect student attitudes and achievement in mathematics.

ABSTRACT

A 2x2x3 randomized block design was employed with 117 seventh grade students to investigate the independent and combined effects of a learning game and student teams on students' attitudes and achievement in mathematics. Multivariate and univariate analyses of variance revealed that students in classes using games were more positive toward math class than students in classes using quizzes. Low and average ability students in team reward classes were more positive toward math class than similar students in individual reward classes, but the reverse was true for high ability students. Students in the games-task classes scored significantly higher than those in quiz-task classes on a test of divergent solutions, but no significant differences were observed on a mathematics computations test.

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INTRODUCTION

The purpose of the present study was to investigate the independent and combined effects of a learning game and student teams on student attitudes and achievement in mathematics.

Learning games are defined as activity structures in which the players (i.e., students) use a body of knowledge as a resource in competition with other players to achieve a stated goal (for example, using vocabulary skills to place first in a class spelling bee). Such games have been used on an ad hoc basis by many teachers to help enliven the dull task of rote learning. Allen and his colleagues (1972) have encouraged more systematic use of the technique by developing a series of learning games based upon a resource allocation model for teaching mathematics (EQUATIONS), word structure (ON-WORDS), set theory (ON-SETS) and symbolic logic (WFF'N PROOF). The rationale for the efficacy of the resource allocation games as learning environments is that:

> "When the resources to be allocated . . . are symbols representing the fundamental ideas of a field of knowledge, the resulting activity can be a powerful instructional interaction. A learning environment can be designed to emphasize interacting peers creating and solving highly individualized problems for each other. In such a learning environment when they are imbedded in games as resources to be used, ideas tend to be voraciously pursued. Players have something to do with the ideas that they are engaged in mastering; they don't merely hear them or express them in print." (Allen, 1972:1)

In essence, using games changes the classroom by creating an interdependent task structure (students work together) and a context in which the knowledge to be learned becomes a useful resource.

A unique feature of the resource allocation games is the tournament used to structure competition. Students of approximately equal ability compete individually in small groups of two or three players. A group hierarchy based upon ability is identified and, after each round, winners and losers in adjacent groups exchange places, with the winners moving up and the losers moving down. Thus, the probability that a given student will receive positive reinforcement (winning a given game) for exhibiting academic skills is approximately one-third. Also, the reinforcement immediately follows the appropriate student behavior. Both probability and immediacy of reinforcement have been shown to be critical factors in learning (cf. Skinner, 1969).

The second instructional technique investigated here, student teams, is highly related to games. Allen has suggested that teams be used as an integral part of his games (Allen, Allen & Ross, 1970). The rationale for using student teams stems mainly from the work of Coleman and others on adolescent subcultures (Coleman, 1959, 1969; Spilerman, 1971). Coleman argues that by structuring team competition in the classroom, peer forces can cause individual students to become more interested and involved in academic tasks, producing concomitant increases in achievement. DeVries, et al. (1971) found a normative peer climate more oriented toward academic involvement in classes using cooperative work groups as compared to classes of students using individual study.

A second observed effect of student teams is increased student peer tutoring (Wodarski, et al., 1971; Hamblin, et al., 1971). When the reinforcement an individual student receives depends on his team's performance, it is

to his advantage to increase the academic akills of his teammates via peer tutoring. The above mentioned studies of student teams have shown team reinforcement to be superior to individual reinforcement for creating student learning. However, the reinforcement was based upon a token economy with material backup and did not involve interteam competition.

Recent research has provided evidence of the efficacy of the games-teams combination for learning (Allen, et al., 1970; Edwards, et al., 1972). However, no studies have investigated the independent and combined effects of games and teams on student attitudes and academic performance. The present study was designed to examine these effects.

METHOD

Subjects, Design, and Procedure

The subjects were 117 seventh grade students in four mathematics classes at a large urban junior high school. The experiment was a 2 x 2 x 3 randomized block design, with the three factors being task (game vs. tests), reward (team vs. individual), and ability (low, middle, high). The students were classified into ability levels on the basis of their previous quarterly math grade, with one-third of the students in each ability level. They were then assigned to task and reward conditions randomly within ability levels. The resulting four treatment groups were almost exactly equal in average ability as indicated by the mathematics subtest of the Iowa Test of Basic Skills and by the Otis-Lennon Mental Abilities test. Less than one percentile point separated the highest and lowest treatment group means on the Iowa math test; and only 2.22 IQ points on the Otis-Lennon test.

Since all four classes in the study met during the first period, the stratified random assignment of students to treatment groups was accomplished without any major changes in the students' schedules. The four teachers involved in the experiment were two men and two women, all in their first or second year of teaching. The experiment lasted four weeks (twenty school days); the classes met for fifty minutes each day. At the end of the second week the teachers exchanged classes, so that each treatment group was taught by a man for two weeks and by a woman for the other two weeks.

The Experimental Treatments

The two levels of the task variable can be identified as "game" and "quiz." Students in the two task conditions received similar instruction for three days each week, but on Tuesdays and Fridays, the "quiz" groups were administered quizzes on the material they had been taught, while the "game" groups played the learning game Equations. This game requires the players to use a given set of digits and symbols (generated by rolling marked cubes) to construct algebraic expressions equal to a specified number. In each "game" classroom there were ten Equations games being played at the same time, with three (sometimes two) students in each game. The students were initially assigned to tables for the game on the basis of ability. After each day's play, the winner at each table exchanged places with the loser at the next higher table. This "bumping" procedure kept the game tables homogeneous in ability while taking into account new learning by the students.

The two levels of the reward variable can be identified as individual-reward and team-reward. The team-reward classes were divided into teams of four students each, in such a way as to have a wide range of student abilities on each team, with all the teams about equal in average ability. Each team was also made as heterogeneous as possible in terms of race and sex. (Almost all the teams were composed of an equal mixture of male-female and black-white students.) Students in all classes were given the opportunity to help each other during practice periods, although each student performed individually in the game or the quizzes. (In the teams conditions teamwork was emphasized.) A newsletter (as recommended by Allen, 1969) was distributed to the students on the second day after each game or quiz period. The newsletter showed individual scores, team scores, and team rankings, both on the most recent game or quiz and (cumulatively) for the "season." Team scores were obtained by summing the scores of the members present for the game or test; no provisions for absentees were made. The students in the team-reward classes were periodically reminded that their math grades would depend partly on their teams' scores, although they did not receive any letter-grades during the experiment. In the individual-reward classes the students were not divided into teams; the newsletter listed only individual scores, and the students were told that their grades would depend on their own performance in the game or the quizzes.

The Dependent Variables

The dependent variables included two tests of mathematics achievement and four questionnaire scales designed to measure the student's attitudes toward math class.

The two math achievement variables represented two levels of specificity of math skills likely to be affected by the experimental treatments. The first achievement variable, representing a general level of measurement, was a forty-item computations test covering the four basic operations with decimals and fractions (the material taught during the four weeks of the study).[1] The test was pretested with a number of seventh-grade classes comparable to those in the experiment and it differentiated the students as expected. A student's score was the proportion of problems he answered correctly.

The second achievement measure, representing a level of measurement specific to the games treatment, was a divergent solutions test developed by the experimenters and employed in a previous study (Edwards, et al., 1972). The test consisted of two items. Each item specified a set of numbers and operations (called "resources"), and the right hand side of an equation (called the "goal"). The students were asked to write as many different solutions as they could that would equal the goal (1/2 and .8 were the two goals used), using only the numbers and operations given in the resources. A student's score was the total number of correct solutions written. The divergent solutions task is a basic skill used in playing Equations.[2]

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[1] Many of the items were taken from the Stanford Achievement Test in Mathematics, computations subtest.

[2] While no reliability or validity data were obtained for the divergent solutions test, it did discriminate well between groups in a previous experiment (Edwards, et. al., 1972).

The four attitude measures also dealt with two levels of treatment specificity. Two of the scales measured a student's general reaction to the math class as conducted during the four weeks of the study. The first scale (called interest in math class) consisted of four Likert-type items such as "I have enjoyed coming to this math class." The students indicated their agreement or disagreement on a four-point scale. The second measure was a semantic differential scale using the stimulus concept "Attending my math class is" and four sets of evaluative bipolar adjectives (fun-frustrating, pleasant-unpleasant, easy-hard, boring-interesting). Responses were made on a five-point scale.

The other two attitude variables dealt with students' evaluations of two specific activities conducted in all four experimental classes. Semantic differential scales were employed with the stimulus concepts "Working with other students in class is . . ." and "Receiving Newsletters in Math class is . . .". The four bipolar adjective pairs listed above formed the basis for a student's responses.

Each of the attitude scales were scored by weighting their items and then summing across items. Item loadings on the first principal

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Insert Table 1 about here
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component derived from the 4 x 4 inter-item correlation matrix were used as item weights for each scale. The loadings for each scale are listed in Table 1.

RESULTS

Math Achievement

Table 2 contains the treatment group means for the computations test and for the divergent solutions test; Table 3 contains the analysis of variance for these two variables. On the computations test, neither the Task (game vs. quiz) nor the Reward condition (individual vs. team) significantly affected the students' scores. The only significant effect

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Insert Table 2 and 3 about here
---

on this test was the main effect for student ability ($F = 49.14$; $df = 2/103$; $p < .0001$), which accounted for nearly half the total variance ($N^2 = .47$). This result is not surprising and provides evidence of the validity of the computations test.

On the divergent solutions test, there was a significant Task effect ($F = 5.01$, $df = 1/81$; $p < .05$) and a significant Task-by-Ability interaction ($F = 3.84$; $df = 2/81$; $p < .05$). These effects are shown graphically in Figure 1. Except at the lowest level of ability, the students in the game

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Insert Figure 1 about here
---

classes produced more correct solutions than those in the quiz classes.

Attitudes

Table 4 contains the treatment group means on the four attitude scales: Math class interest, attending class, receiving newsletters, and working

with others. Table 5 contains the results of the multivariate and univariate analyses of variance for these variables. The multivariate analysis revealed a significant Task main effect ($F = 4.42$; $df = 4/95$; $p < .01$). The univariate analyses indicated a significant Task effect on each of the four attitude scales. In each case, the mean for the game classes was higher than for the quiz classes. That is, the students were more positive toward the games classes.

Insert Tables 4 and 5 about here

The univariate analyses also revealed a significant Reward effect for the variable Math Class Interest, with the teams classes being more positive than the individual classes. A significant Reward-by-Ability interaction resulted from the fact that the positive effect on attitudes due to the use of students teams was strongest for low ability students, somewhat positive for middle ability students, and somewhat negative for high ability students. The interaction is shown graphically in Figure 2.

Insert Figure 2 about here

In summary, the games treatment consistently created more positive student attitudes toward the class. Adding student teams affected only one of the four attitude measures, and this difference was due primarily to the greater interest expressed by low ability students.

The attitude and achievement profiles for each of the four treatment groups are given in Figure 3. To facilitate the graphing of all variables on a comparable scale, the cell means for each variable were transformed using the following formula: $Z = \frac{\text{cell mean - grand mean}}{\text{S.D. of cell mean}}$.

As can be seen from the profiles, the two games classes have consistently more positive attitudes than the two quiz classes.

Insert Figure 3 about here

DISCUSSION

The results of the present study suggest that the games aspect of the games-teams technique produces the larger effects on attitude and achievement variables. Such effects may be attributable to the novelty, concreteness, and socially interactive nature of the games task. The playing of Equations represents a marked departure from typical mathematics activities. In the present study, the games were played for 50 minutes, twice a week; it is an open question as to how much game playing could be employed before the novelty effect would wear off. Concreteness of the task (e.g., providing manipulable materials) has been shown to relate to positive attitudes toward math with other materials such as cuissenaire rods (Dieren, 1969) and comprises another plausible explanation for the Game effects.

On a posttest question asking the students if they enjoyed the games, 94 percent indicated yes. The major reason given for their response was the social interaction involved.

An interesting result was obtained for the attitude "Math Class Interest" in the significant Teams-by-Ability interaction. As Figure 2 indicates, at the low and middle ability levels the teams students had higher scores but the situation was reversed for the high ability students. On the posttest questionnaire, of the 21 percent who indicated a negative opinion of teams, 67 percent were high ability students. These results may be due to the fact that the low ability students had the most to gain and the least to lose in a team situation and vice versa for the high ability students. While we feel this is a reasonable interpretation, the significant interaction should be viewed with some caution since the multivariate F for the effect was not significant.

Significant effects on achievement were limited to the treatment-specific Divergent Solutions test, with the games groups having higher scores. There were no differences for the Task factor on the computations test; no differences for the Reward factor were observed on either of the two achievement measures. Given the favorable attitudes and classroom processes created by games and the games-teams combination (see DeVries and Edwards, 1972b for effects on process variables), the lack of achievement differences may have been due to the fact that the experiment was too short (50 minutes per day for 20 days with 3 days out for testing). The first three or four times (first two weeks) the students played Equ[illegible]s, they were preoccupied with learning the game rules. Students also needed time to adjust to working together as a team. Initially, team members were at a loss as to how to help one another.

Students had to be coached by the teacher on how to improve their team's performance. The treatment groups were just beginning to coalesce when the experiment terminated. In a previous study by the authors using the games-teams combination over a nine-week period, significant math achievement differences on both specific and general measures were obtained (Edwards, DeVries, & Snyder, 1972).

The results on attitude and achievement variables reported in the present paper, together with results outlined in other papers by the authors on classroom process (DeVries and Edwards, 1972b), and cross-race cross-sex interaction (DeVries and Edwards, 1972a), provide a comprehensive map of the independent and combined effects of games and teams. Teams increase cross-race and cross-sex interaction, promote mutual concern, and result in increased peer tutoring. Games increase students' satisfaction with math class, decrease the perceived difficulty of the class, create generally positive attitudes toward class, and teach additional math skills.

For the most part the effects of games and teams are additive. The one exception is in perceived competitiveness of the class. The class with teams and games was considerably less competitive than the class with teams only. Thus, games and teams can be viewed as complementary techniques, which, when used together, substantially alter the social and affective climate of the classroom.

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Table 1

First Principal Component Loadings for Four
Math Attitude Scales

	SCALE			
ITEM	Math Class Interest	Work With Others	Attend Class	Receive Newsletter
1	.807	.831	.781	.722
2	.696	.907	.811	.857
3	.671	.681	.325	.548
4	.865	.878	.820	.824

Table 2

Treatment Cell Means for Two Measures of Mathematics Achievement

TREATMENT CONDITION		Computations Test	Divergent Solutions Test
Quiz	Individual	46.93 (N=30)[1]	2.00 (N=25)
	Teams	40.71 (N=31)	1.85 (N=20)
Games	Individual	44.20 (N=25)	3.32 (N=22)
	Teams	43.90 (N=29)	2.42 (N=26)

[1]The numbers in parentheses are the sample sizes. The numbers are not the same across measures within a group because the tests were given two days apart and not all the same students were present on both occasions.

Table 3

Univariate Analyses of Variance of
Two Measures of Math Achievement

	COMPUTATIONS TEST		DIVERGENT SOLUTIONS TEST	
SOURCE	df	F	df	F
TASK (A)	1	< 1	1	5.01* (n^2=.05)[1]
REWARD (B)	1	2.15	1	1.76
ABILITY (C)	2	49.14** (n^2=.47)	2	1.00
A x B	1	1.40	1	< 1
A x C	2	< 1	2	3.84* (n^2=.08)
B x C	2	1.04	2	< 1
A x B x C	2	< 1	2	< 1
ERROR	103		81	

*p < .05
**p < .0001
[1] n^2 = Eta-square

Table 4

Treatment Cell Means for Four
Attitude Scales

	TREATMENT CONDITION	MATH CLASS INTEREST	ATTEND CLASS	RECEIVE NEWSLETTER	WORK WITH OTHERS
QUIZ GAMES	INDIVIDUAL (N = 27)[1]	6.55	9.50	11.10	11.13
	TEAMS (N = 30)	7.82	10.12	11.85	12.55
	INDIVIDUAL (N = 26)	8.62	11.03	13.00	13.90
	TEAMS (N = 27)	9.08	11.15	12.23	13.59

[1]Numbers in parentheses are sample sizes. They differ from those in Table 1 because the attitude scales were administered on a different day than the two achievement measures.

Table 5

Multivariate and Univariate Analyses of Variance
of Four Attitude Scales

MULTIVARIATE			UNIVARIATE				
Source	df	F	df	F Math Class Interest	F Attend Class	F Newsletters	F Work With Others
TASK (A)	4/95	4.42**	1	13.53*** (n^2=.10)[1]	10.17** (n^2=.09)	6.49** (n^2=.06)	9.44** (n^2=.08)
REWARD (B)	4/95	< 1	1	3.85* (n^2=.03)	< 1	< 1	< 1
ABILITY (C)	8/190	1.53	2	4.28* (n^2=.06)	3.76* (n^2=.06)	< 1	1.58
A x B	4/95	1.03	1	< 1	< 1	3.08	2.34
A x C	8/190	< 1	2	< 1	< 1	1.07	< 1
B x C	8/190	< 1	2	3.13* (n^2=.05)	< 1	< 1	< 1
A x B x C	8/190	< 1	2	< 1	< 1	< 1	< 1
ERROR			98				

*p < .05
**p < .01
***p < .001

[1] n^2 = Eta-square

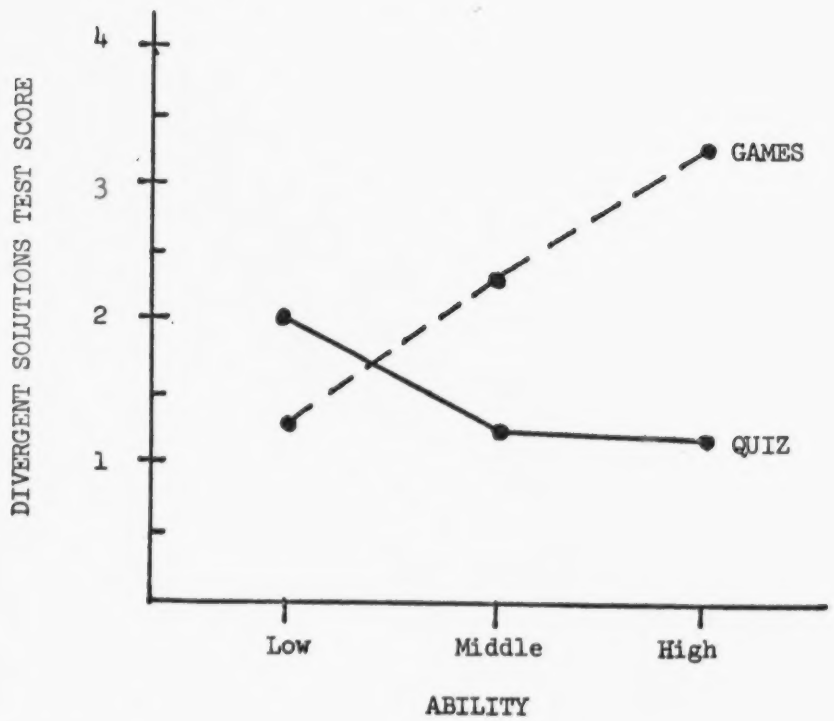


Fig. 1 - Task-by-Ability Interaction

On Divergent Solutions Test

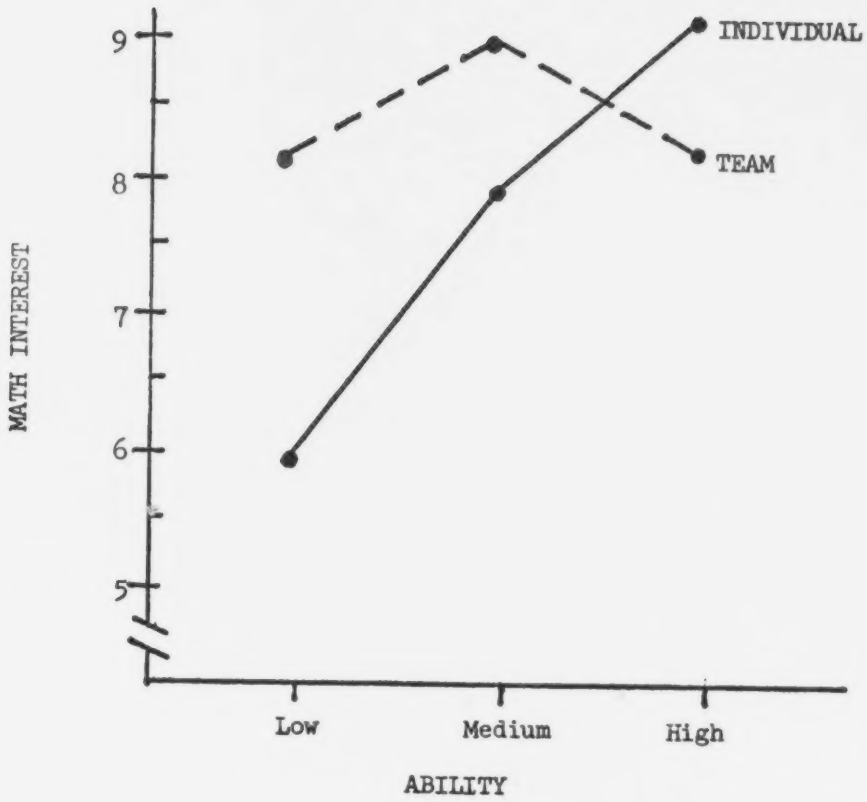
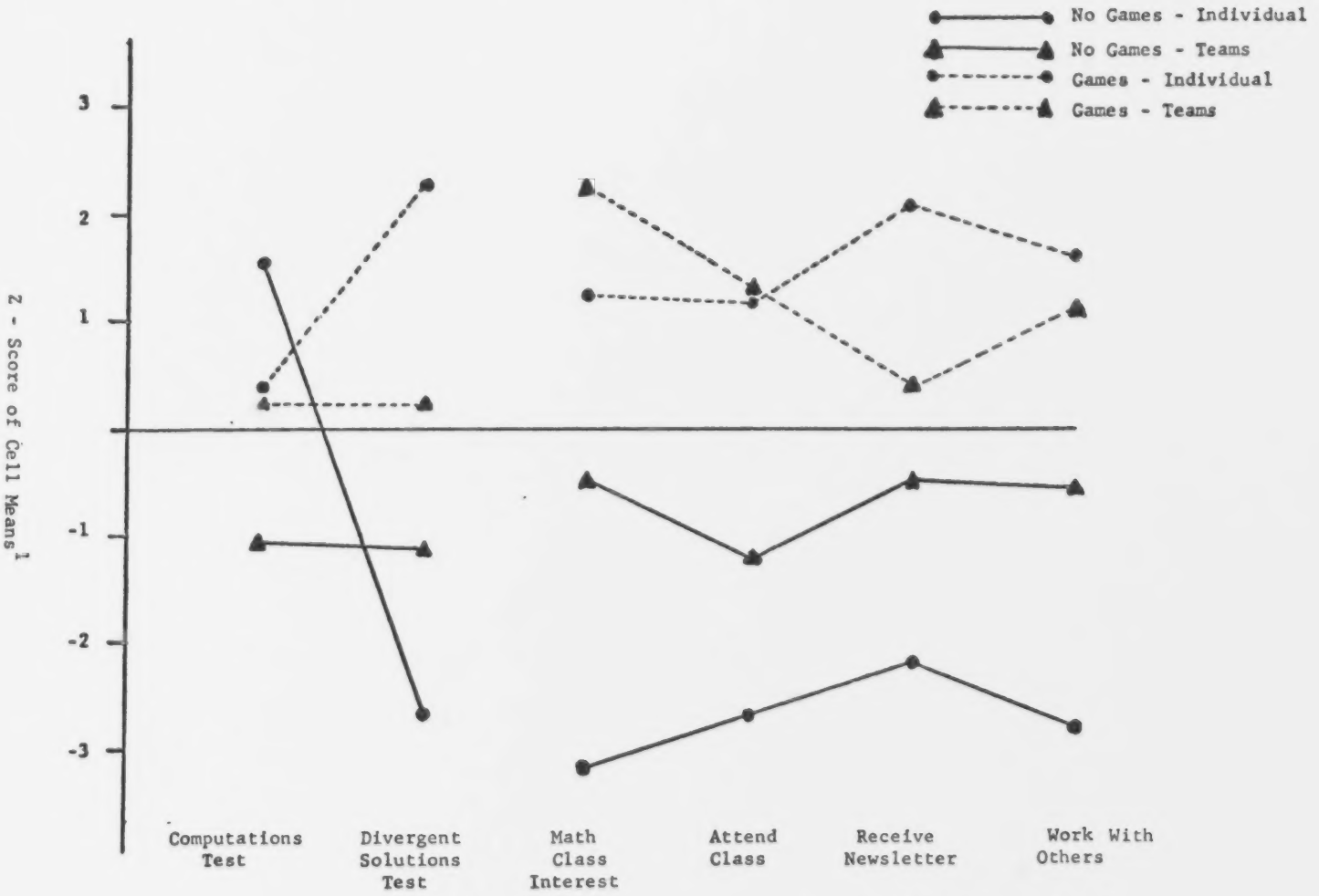


Fig. 2 - Reward-by-Ability Interaction

On Math Class Interest Scale



$^1Z = \frac{\text{cell mean - grand mean}}{\text{S. D. of cell means}}$

Fig. 3 - Standardized Treatment Profiles
On Attitude and Achievement Variables